ENGINEERING SURVEY PROCEDURES for STRUCTURAL MEASURES IN WATERSHED PROJECTS

TECHNICAL RELEASE, EWP-NO. 5

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

ENGINEERING & WATERSHED PLANNING UNIT
UPPER DARBY, PENNSYLVANIA

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ENGINEERING

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The purpose of this technical release is to encourage and provide aid in obtaining uniformity among the Northeastern States in regard to engineering surveys for structural measures included in watershed projects. It sets forth the amount of detail, survey criteria, and survey methods considered acceptable for both the work plan development phase and the final structural design phase of watershed projects. This release supersedes Section C of Chapter 6 of the "Work Plan Party Guide for the Northeast." All copies of this section should be marked "Superseded by Technical Release EWP No. 5."

To facilitate the use of the release, the subject has been divided into the following chapters:

Chapter 1 - Survey Procedures for Floodwater and/or Water Impounding Structures

Chapter 2 - Survey Procedures for Channel Improvement Work

Additional chapters may be added for other types of structures if a need develops for such information.

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CHAPTER 1 - SURVEY PROCEDURES FOR FLOODWATER RETARDING AND/OR WATER IMPOUNDING STRUCTURES

I - GENERAL

A. Use

The procedures are applicable to all impounding structures requiring flood routing.

B. Survey Detail Recommended

For work plan analyses, the decision as to the detail required and the survey method used should be based on the topography, density of tall cover and underbrush, the cost of the survey, and the probable economic feasibility of the site. In some cases, it may be economically sound to make a detailed survey that would meet the requirements for final design. In any case, surveys made to develop the work plan should be recorded in field note books in accordance with Engineering Memo SCS 39 (Rev.) 1-27-60 and referenced in the field in a manner that will not require duplication in the final design surveys.

All significant physical features should be located and elevations of strategic points recorded. Such features as buildings, cemeteries, churches, apparent farm and land ownership boundaries, fences, pipelines, power and telephone lines, springs, wells, etc., that may affect design or easements and rights-of-way, should be recorded during the topographic survey.

Public roads within the pool area should be located accurately and profiles run along the sections which are below the estimated maximum flood elevation. The elevation of the channel center line at points of intersection with apparent property lines should be noted. Sufficient topographic data should be obtained in the pool areas during the work plan stage to permit development of stage-storage data adequate for final design. Such topographic data also should be complete enough in the pool area to define flowage easements needed for use in preparing land rights maps.

When the economic justification of individual or groups of structures is questionable, it may be advisable to make the field surveys in two steps. During the first step sufficient information such as a profile of the pool area, a profile of the fill center line, and two or three cross sections of the pool area should be obtained to determine approximate storage and cost data. Sometimes this step is needed during the preliminary investigation. If the site or group of sites appears to have sound economic justification, additional surveying

should be done in the second step to meet the requirements listed below.

C. Survey Criteria

1. Vertical Datum - It is preferable to establish mean sea level elevations at each site by a closed level circuit from a source of established elevation. The manuscript sheets used by USGS for vertical and horizontal control are a good source both for permanent elevation data and for useful elevations at road intersections, etc. for rough closure checking. A description of the source should be recorded. In locations where it would be too costly and time consuming to establish mean sea level elevations, it is recommended that all engineering surveys within a watershed be based on a common assumed datum to aid in flood routing work and tying channel improvement work to floodwater retarding structural measures.

2. Bench Marks - At least two permanent bench marks should be established at each site. It is desirable to have one or more set at elevations well above the proposed top contour, and located completely outside the anticipated construction area. It is convenient also to have another permanent bench mark established in the flood plain immediately below the structure site and several TBM's (5 or 6) scattered throughout the pool area. All bench marks, both permanent and temporary, should be properly referenced in accordance with recognized procedures given in engineering survey handbooks.

   The bench mark may be a plate set in concrete, a plate on a concrete post similar to those used by USGS, or other similar means that will give the same degree of permanency. Manufactured survey markers, consisting of steel stakes with bronze caps, are sometimes used because they are relatively inexpensive and can be set quickly and easily. Where manufactured markers are not used, it is advantageous to tag each bench mark with an aluminum tag showing the bench mark number and elevation.

3. Permissible Error of Closure - The error of closure for a bench level circuit should not be greater than $0.1\sqrt{M}$ feet, "M" being the length of circuit in miles.

   The error of closure for horizontal control for a closed traverse survey shall be not greater than $1.5\sqrt{N}$ minutes, "N" being the number of angles in the traverse, nor greater than 1.0 foot per 1000 feet of traverse length (3.0 feet per 1000 feet for stadia). For open traverse surveys, all angles should be doubled and/or checked by

comparing computed bearings with observed bearings. Other more precise methods as described in any standard surveying textbook may be employed if desired.

4. Contour Interval - The following is a guide to the desired contour interval of the pool area map: A 2-foot contour interval is suggested for slopes up to 4 percent, a 4-foot interval for 4-20 percent slopes, and a 10-foot interval where slopes exceed 20 percent. To permit consideration of alternate designs, the topographic surveys should extend to the top of the dam or higher where necessary. Surveys around the structure should be sufficient to design the structure including the emergency spillway.

   After preliminary designs have been developed, contour lines at the elevations of the principal spillway crest, emergency spillway crest, and the elevation of maximum design flow through the emergency spillway may be established to define the area needed for the acquisition of land, easements, or rights-of-way, as prescribed in Chapter 2, Part 2, Paragraph 2204.13 of the Watershed Protection Handbook dated 4-1-61. In some cases it may be desirable for easement and right-of-way purposes to also stake the borrow areas at this time.

D. <u>Drainage Area Boundaries</u>

1. Main and Subwatershed Boundaries - Where adequate USGS quadrangle maps are available, these maps usually are the most accurate maps available for delineating and planimetering the main and subwatershed drainage areas. It is well, however, to check the watershed by means of stereoscopic study of either the 4-inch or the 8-inch = 1 mile scale aerial photos. Any questionable points or boundary lines which differ significantly from the original quadrangle map should be checked in the field and appropriate corrections made on the maps before planimetering. This step should be done preferably in the preplanning stages to avoid the need for revisions as the planning work progresses.

2. Boundaries for Structure Sites - The drainage areas of floodwater and other water impounding structures should be determined carefully to permit use both for planning and for final design purposes.

   Where adequate quadrangle maps are not available for use as described in Item 1 above, the watershed boundaries for each structure site should be outlined on available (4-or 8-inch) aerial photographs, using the center 1/3 to 1/2 of each consecutive photograph. This should be

done by (1) stereoscopic inspection checked with available quadrangle maps, and (2), where it cannot be determined readily by stereoscope or quadrangle maps, the delineation should be made by field inspection. Natural divides or manmade diversions which may be considered permanent should be followed. Terrace systems and small diversions which may fail during large storms should be disregarded.

The scale of the photograph should be verified. If not already done (by ASC or others) the scale should be accurately established on at least one print of each flight line crossing the drainage area above each structure. This may be done by measuring two lines approximately perpendicular to each other. These lines should be selected between readily identifiable points within the center part of the photograph and along an established line such as a road or fence.

The size of the drainage area in acres normally is determined by planimetering accurately the delineated area on the photographs. For large drainage areas involving several prints it may be advisable to make an overlay of the area in order to obtain a higher degree of accuracy in planimetering, or delineate the drainage area on USGS quadrangle maps as suggested above for the main watershed boundaries. Where no suitable maps are available, the drainage area boundary should be established by a transit survey.

II - SURVEY PROCEDURES FOR WORK PLAN DEVELOPMENT

A. Pool Area Topography

A complete topographic survey of the pool area should be made. The steps normally followed in making site surveys are:

1. Establish and reference a permanent baseline. A baseline may be established with a minimum of two permanent reference points which may serve also as bench marks, depending on local conditions and alignment of the dam, for horizontal and vertical control. This baseline may be the initially selected center line of the proposed dam. A minimum of two transit points should be set on the baseline and referenced horizontally and vertically to easily identified permanent points. In the event the final center line differs from the initially selected center line, new transit points properly referenced should be established on the final line as described above.

It is frequently desirable to have two base lines carefully tied together, one on the centerline of the proposed dam and one through the proposed pool area.

2. Establish vertical control at the site. Use sea level datum if suitable elevations are available within a reasonable distance (5 miles).

3. Develop the topographic map. The topographic map may be plotted while the survey is in progress, or in the office from survey notes, depending on the method of survey used. Listed below are several acceptable methods of making this survey.

Method 1 - In open country the conventional planetable survey, using the telescopic alidade and obtaining distances and elevations by stadia and Beaman Arc or vertical angles, usually is the most rapid and economical method of obtaining topography.

Horizontal control should be established by selecting stations for a closed traverse and several key points in the area and tying these points to the base line. These points should be strategically located on the ground and plotted accurately on the planetable sheet for use as references in orienting the planetable. They may be actual planetable stations. After the initial orientation on the site between two bi-visible stations, the planetable may be oriented with the compass needle. For sites of less than 2000-2500 foot stream distance, a planetable closed traverse may be used, depending upon the ability of the mapper. For greater distances, the use of a transit traverse is recommended.

Vertical control should be established by running a closed line of differential levels through the traverse stations and key points throughout the pool area and setting a sufficient number of temporary bench marks at strategic locations to allow frequent checks by the mapper and for future reference. Care should be used in laying out the traverse stations so that adequate coverage is obtained and errors are not carried forward in succeeding setups. If the site involves physical limitations, several ownerships, or productive lands, key contours should be located on the ground as described in Method 4. To accomplish this it may be found more convenient to use an engineer's level in conjunction with the planetable or transit for actual location of the contour lines on the ground.

Method 2 - Topographic information may be obtained in note form by use of the transit as the traverse is

being surveyed for horizontal and vertical control. All information for the complete topographic map is recorded while the transit occupies the various stations. Except for vertical control, which is kept current, notes are reduced later for plotting. Vertical angles or Beaman Arc readings and stadia distances are used for computing elevations.

When using the transit, a minimum of two readings on all turning points taken with the telescope in a leveled position is recommended for vertical control. As an alternative, vertical control may be established with an engineer's level as described in Method 1. The traverse is computed and balanced before plotting the topographic information to develop a map. Key contours should be located on the ground as described in Method 4.

Method 3 - In heavily wooded sites, it may be more convenient to stake one or more base lines through the pool area. Hubs should be set on each transit station. The horizontal control can be obtained by running a closed transit traverse or by using the mean reading obtained by doubling each deflection angle and recording carefully observed bearings of each line as a check against a gross error. The traverse notes should be checked for permissible error of closure and plotted accurately.

Topographic data is obtained from a series of cross sections which are usually run perpendicular to the base line.

In the selection of locations for cross sections, care should be taken to obtain a section through each draw or significant indentation. Additional sections taken perpendicularly to this section will be necessary to show the contours in the draw with desirable accuracy. Ridges or large promontories should receive similar attention.

Hubs and guard stakes should be set on or near the extremities of each cross section for future reference in locating water lines, etc. These hubs also serve as useful TBM's. A closed circuit of differential levels should be run to establish the bench mark elevations. Elevations along the cross sections may be obtained with a transit using vertical angles and stadia distances, or a level and tape may be used.

The notes may be computed and plotted in the office or the base line and cross sections may be plotted and used in the field similar to a planetable map. If the

engineer considers it expedient, a level party may be used in connection with a planetable or transit party for the purpose of obtaining elevations at critical points between cross sections. The accuracy with which these contours can be sketched in will be determined by the uniformity of the slopes and the number and location of the cross sections selected.

Method 4 - The key-contour method is a variation of the planetable survey Method 1. This survey is made with a level and planetable. The key contours are run with the level and located on the planetable map with the telescopic alidade. A transit, set up beside the planetable, may be substituted for the telescopic alidade to read the azimuths and distances. The points are quickly plotted using a special plotting protractor. (The Cartographic Unit of Milwaukee, Wisconsin lists such a protractor under the number 3-0-2820. Those made of metal are preferred over those made of cardboard.) While running the key contours, rod readings can be taken to locate the next contour above and below the key contour. The number of key contours required will be governed by the difference in elevation in the area to be mapped.

This type of survey requires a closed traverse to locate planetable stations, which are established to afford coverage of the area to be mapped. The use of two or three rodmen, each running out a separate contour as directed by the level man, will increase the efficiency of this method.

Method 5 - Where suitable 8-inch aerial photographs are available (or enlargements to any other convenient scale such as 1"=200, 300, or 400') which show sufficient detail to locate and identify base lines and pool cross sections, usually it will not be necessary to run a transit traverse to locate base lines or cross sections. It will be necessary, however, to verify or establish the true scale of the photograph in order to locate properly the intersection of the contours with the cross sections and base lines. Since the scale changes near the outside edge of the photograph, it may be necessary to establish more than one scale for each map. This depends on the size of the pool area and its relative position on the photograph. The center one-third of the aerial photographs have the most nearly uniform scale. Cross sections will be located on the photograph to give adequate coverage of the entire pool area. Usually it is convenient to use fence lines, power lines and road rights-of-way for cross sections. Normally, these will have to be supplemented with additional lines located on the points of ridges, along slopes, and between

points that are identifiable on the photograph.

After the cross sections have been selected and located on the ground, temporary bench marks normally should be set at points at or near the upper or both extremities of each line, depending on local conditions. Differential levels then should be run to establish the bench mark elevations. The extremities of each cross section should be lettered or numbered on the map to facilitate note keeping. Level notes for each line will reflect clearly the direction in which the surveys were made, such as "Section A-B, from B to A". The contours will be identified and located by station numbers on the cross section notes, such as Contour 872.0, Sta. 3+62.

The intersections of cross sections and contours are determined next by the use of an engineer's level and chain, or a transit or planetable and stadia. The location of each contour elevation is determined and the distance between contours measured along the cross section. These points are plotted on the cross sections drawn on the photograph and the contours sketched in between cross sections. In many cases a stereoscope is useful as an aid in sketching contours. <u>More accurately located contours usually will result if the mapper sketches in the contours between cross sections while on site where he can see the area being mapped</u>.

An alternate method is to survey cross sections by taking level readings at 100-foot stations and all breaks in slope and locate the intersection of contours and cross sections by interpolation. Interpolation may be done more accurately by plotting cross sections on cross section paper and noting the points of intersection with respective contours. The top contour, or key contour at the estimated emergency spillway crest elevation, may be located on the ground with a level and sketched on the aerial photograph while establishing the elevations of the ends of the cross section lines. <u>This method has the advantage of having the contour map laid out on an aerial photograph which makes it easy to see the location of flowage easements needed</u>.

Method 6 - The photogrammetric method of obtaining topographic data is being used more and more. It is especially useful in rugged terrain, heavily wooded with decidous trees. The method involves the taking of low (average of 3000-5000 feet) altitude aerial photographs of the site during the dormant season of the year and when there is no snow cover. Prints are made and diapositive glass plates are prepared for those exposures which provide adequate coverage of the area. A pair of consecutive exposures are known as models. These models are placed

in the Kelsh plotter, one pair at a time. Special colored light is projected through the models which produces a third dimensional view of the photographs on a plotting table. Before the operator is able to plot contour lines he must adjust the plane of the models to provide the desired plotting scale and the correct vertical orientation. These adjustments require certain ground control data. The horizontal scale is determined as described earlier in Section I-D-2 "Watershed Boundaries for Structure Sites." For vertical control the elevations of a minimum of three and preferably four or more points near each of the four corners of the usable (center 1/3) portion of each photo and visible on each photograph of consecutive pairs must be obtained in the field. These points may be selected after the photos have been taken or hubs may be set in carefully selected locations prior to photographing the area. In the latter system, the hubs are marked with cheesecloth or other means which can be seen readily from the air.

Because of the specialized nature of this work, all contracts for low altitude aerial surveys are handled through the Beltsville Cartographic Unit. The necessary ground control work also is arranged through this Cartographic Unit. (Reference: Administrative Services Division Handbook, Section 241, dated 12-29-60; also Cartographic Memorandum SCS-2, July 26, 1955).

B. Construction Area

1. Embankment Area - At most sites sufficiently accurate estimates of quantities and cost can be made for work plan purposes from a profile run along the proposed center line of the embankment if care is exercised in getting readings on each significant break in ground surface. Fill yardage may be obtained by the average end area method based on the center line height of the dam above the valley floor. One method for determining the value of "height" is to:

   a. Compute the effective height of dam above the respective points along the center line of the fill.

   b. Add 0.5 foot for site preparation, except on sites which have heavy brush or timber. In these cases 1.0 foot should be added.

   c. Add 1.0 foot for core trench, stream channel backfill, spillway dikes, levees, etc. (Core trenches, levees, dikes, etc. may be computed individually. If so, the 1.0 foot should not be included in the embankment computation).

d. The appropriate settlement factor should be applied to the sum of a, b, and c above.

At unusual sites, it may be necessary to cross section the foundation area as described in Part III of this Technical Release in the section "Embankment Center Line Profile and Cross Sections."

For preliminary estimates or where the settlement factor is expected to be three percent or less and items listed in "c" above are not significant, sufficiently accurate estimates may be obtained by adding 10 percent to the total yardage obtained by using the effective heights determined in "a" above in lieu of computing items "b", "c", and "d".

2. Emergency Spillway Area - For all sites, the pool area topographic survey <u>should include all areas which may be used for the emergency spillway or for additional borrow areas</u>. At unusual sites where it is anticipated it will be difficult to construct the required emergency spillway or where rock excavation will be encountered, a complete layout of the emergency spillway should be made in order to obtain reasonably accurate quantity and cost estimates. This layout should include a profile along the center line of the spillway and cross sections at critical locations along this profile. Rock elevations should be spotted on the profile and cross sections in order to obtain a reasonably accurate quantity and cost estimate of rock excavation needed. A more detailed description is given in Part III in the section "Emergency Spillway".

Where more than one choice of spillway location exists, sufficient topographic data and other information should be obtained to analyze each location and arrive at the most desirable plan. Sufficient topographic information at each location should be obtained to permit a change of alignment to a physically more desirable or less costly location without having to go back to the field for additional information.

III - SURVEY PROCEDURES FOR FINAL STRUCTURAL DESIGN

A. <u>Coordination with Work Plan Data</u>

In completing the surveys for structural design, all data collected and recorded should be referenced to previously established base lines for both horizontal and vertical control. The engineer in charge of detailed surveys should satisfy himself as to the completeness and accuracy of the work plan data which includes (1) Drainage Areas, (2) Site Topography, and (3) Site Storage Data. Recommendations concerning the elements to be surveyed, the data to be obtained, and the degree of accuracy involved in obtaining these data are listed below for consideration in making the final site surveys for design.

B. Embankment Center Line Profile and Cross Sections

1. Staking - The center line of the embankment should be established with hub stakes using tack points at all angles in the alignment and at the extremities of the center line on each abutment. These extremities should be located well outside the probable construction area. To aid in obtaining profiles and cross sections, temporary bench marks should be set at convenient locations.

   Intermediate stakes should be set at intervals not greater than 100 feet or at such other points as necessary to obtain a true profile and accurate cross sections. To improve uniformity and conform to current watershed operations, the zero station of the center line of the embankment shall be located on the right side of the stream looking downstream. If the spillway is located in the right abutment, the zero station should be located well outside the expected limits of the spillway cut. If the embankment center line consists of more than one tangent, the curve locations should be staked on chord lengths not greater than 50 feet where the degree of curvature is 14 degrees or less and 25 feet for curves greater than 14 degrees.

2. Profile and Cross Sections - Profile levels of the embankment center line and cross sections of the proposed embankment foundation area should be taken at all significant breaks where necessary to reflect a change in ground slopes within the foundation area. To improve the accuracy of yardage computations, cross sections should be taken at intervals not greater than 100 feet when the slope is 4 percent or less. This interval should be reduced to 50 feet on slopes from 4 percent to 8 percent and to 25 feet on all slopes over 8 percent.

   In cross-sectioning the foundation area each section should be extended beyond the proposed toe of the embankment slopes a distance equal to the proposed height of the embankment fill, and should include sufficient elevation points to represent accurately all breaks in ground surface. All cross sections should be taken normal to the center line of the embankment.

   All recorded rod readings and elevations for profiles and cross sections should be made to the nearest one-tenth foot. All level circuits should be closed within allowable tolerances as stated in Part I of this release.

C. Emergency Spillway

1. Location - Extreme care should be exercised in locating the emergency spillway in order to obtain alignment which

will result in the most economical plan consistent with existing criteria. (See Technical Release No. 2 and Washington Engineering Memorandum SCS-27).

2. Staking - The center line of the emergency spillway should be aligned with a transit, setting tack points at each transit station. Intermediate stakes should be set at 50-foot intervals and at such other points as necessary to obtain a true profile and accurate cross sections. If the center line of the emergency spillway intersects the center line of the embankment, the point of intersection should be marked with a tack point and the station on each line should be recorded in the field notes, as well as the angle formed by the two lines. If the emergency spillway does not intersect the embankment center line, the two surveys should be tied together by angles and distances. Where a curved alignment is necessary in the approach section of the emergency spillway, the radius of curvature of the center line should be not less than one-half the base width of the spillway plus 50 feet. In staking curved sections the center line stakes should be set on chord lengths of not more than 25 feet. The zero station on the spillway should be located upstream from the approach section and at least four feet vertically below the elevation of the crest of the emergency spillway.

3. Profile and Cross Section - A profile will be developed for the center line of the emergency spillway with elevations taken at each stake set in accordance with paragraph 2 above.

   Emergency spillway cross sections should be taken normal to the center line and at each profile point. These cross sections should be extended outside the bottom width a sufficient distance to include all cut slopes and spillway dikes. All ground elevations should be recorded to the nearest one-tenth foot.

   Many times it is easier to grid this area initially. After design is completed and before construction begins, the center line and slope stakes can be set.

D. Principal Spillway

1. Location - The foundation conditions may determine the final location of both the principal spillway and the emergency spillway. Since detailed geologic investigations have not been made at the time the detailed surveys are made, alternate locations should be considered for the principal spillway based on known general geology of the area and surface topography. Where foundation conditions will permit, the location should be selected that will minimize the problem of downstream release.

In most cases the location can be made so that the outlet pipe is normal to the center line of the embankment. However, some sites may require setting the axis of the outlet pipe at an angle with the center line of the embankment to provide better foundation conditions under the structure or better discharge conditions at the outlet end.

2. Staking - When the location and alignment of the principal spillway have been made, the center line should be staked with a transit, setting tack points at all angles in the alignment and at the intersection with the center line of the embankment. The station of this point on each line should be recorded in the field notes, as well as a deflection angle formed by the two lines. Intermediate stakes should be set at 50-foot intervals and at breaks in surface grade which will be significant in profiling and cross sectioning. The zero station of the center line of the principal spillway should be set not less than 75 feet upstream from the toe of the proposed embankment.

3. Profile and Cross Sections - Profile levels should be run along the center line, starting at the zero station and extending past the discharge end of the structure, and along the stream bed a sufficient distance to determine the stream gradient and any high-spots or control points in the channel. This distance should not be less than 800 feet unless it is obvious that the control points, such as culverts, will control the gradient to be used. Cross sections should be taken normal to the center line at each profile station throughout the limits of the structure and the proposed outfall channel. The distance out from the center line to which cross sections should be taken is governed by the depth of the excavation necessary for the installation of the conduit and any other probable excavation. The minimum section should be not less than 25 feet each side of the center line.

E. Other Survey Data Required

To assist the design engineer in detailing other installations that may be required, such as foundation drains, relief wells, etc., it will be necessary to locate the flow lines and banks of the old stream channel, and any other drainage channels that may be within the embankment area. This information usually can be obtained by extending the cross sections perpendicular to the center line of the principal spillway sufficiently to cover all old stream channels within the embankment area.

F. Location of Areas to be Cleared, and Cleared and Grubbed

To estimate the amount of clearing involved in the construction at any particular site, it will be necessary for the design engineer to know the location of all trees, stumps, and brush within the prescribed areas to be cleared. Since the exact elevations of the pool area to be cleared are not known at the time these surveys are made, the areas that might possibly be involved in clearing or clearing and grubbing should be delineated on the topographic map, with a notation as to size of trees and amount of cover. The areas normally requiring clearing and grubbing are the embankment foundation area, emergency spillway area, and borrow areas. The sediment pool areas normally require only clearing. The outline of groups of trees should be extended well outside the probable sediment pool and the construction areas. It is suggested that these areas be shaded or cross-hatched on the topographic map for proper emphasis.

G. Location and Survey of Borrow Areas

In many sites, the borrow areas may be located on the topographic survey map. If the topographic survey does not contain reference lines convenient to all borrow areas, additional base lines should be staked and elevations taken at each station. The locations of all test holes, samples, and other pertinent borrow conditions, such as springs, rock outcrops, etc. should be accurately referenced to these base lines. This may be done by a random system of survey, using stadia distance from a specific base line station together with the deflection angle from the base line to the respective points.

In borrow areas of irregular topography, the contour interval of the topographic map may not be adequate for accurate computations of available borrow. This is especially important where the quantity of material available is critical. For such areas and where a reference system is desired prior to the geologic investigation, a grid system may be employed to survey and lay out the borrow areas. The most convenient method of gridding borrow areas is to stake out grid lines parallel to an established base line or fill centerline. These lines can be designated by letters A, B, etc. with stations along the lines corresponding to station numbers on the base line. The grid interval selected is dependent upon the topography. However, 100- or 200-foot intervals are common. After the grid lines have been staked, each grid line should be profiled, and elevations recorded to the nearest one-tenth foot at each station and at significant breaks to reflect the profile of the surface of the ground. All test hole locations and other data should be referenced accurately to the grid coordinates.

CHAPTER 2 - SURVEY PROCEDURES FOR CHANNEL IMPROVEMENT

I - GENERAL

A. Applicability -

The procedures described below are applicable to all channel improvement work in watershed projects. The works of improvement may range from the clearing and snagging of existing water courses to the construction of entirely new channels or floodways including dikes and levees, diversions, etc.

B. Effect of Project Objectives on Surveys -

The type and extent of surveys required will depend on the kind of improvement needed to meet the objectives of the project. Service policy, as clearly set forth in the Watershed Protection Handbook, requires that channel improvement shall be considered as supplementary to floodwater retardation rather than as an alternate measure, providing floodwater retardation does not result in unreasonable costs to achieve the same objectives.

The degree or level of protection to be afforded by the project will be dependent upon existing or potential hazards and possibilities for development. It frequently is not feasible to satisfy all possible watershed needs because of either physical limitations or economic considerations.

For urban areas, the highest feasible level of protection should be sought. As a minimum, Service policy requires that the works of improvement provide protection against major flood damages resulting from a recurrence of the largest storm of record or from the 100-year frequency storm, whichever is greater.

For agricultural areas, there is no inflexible rule regarding the level of protection that should be provided. The general objective, however, should be to reduce the hazards from flooding to a point where they are no greater than other risks inherent in agriculture, or to permit development of the area to its best potential use in accordance with economic and other trends.

The following table is suggested as a guide for selecting the range of percent chance of flooding, above which it may not be considered profitable to provide protection for agricultural use or for restoration of former agricultural productivity.

Percent chance of damaging floods in any year	Frequency of damaging flood	Predominating agricultural development
50% to 33%	2 - 3 yr.	Hay and improved pasture
25% to 12½%	4 - 8 yr.	Cultivated crops easily damaged by flooding
10% to 5%	10 - 20 yr.	High value crop such as truck crops easily damaged by flooding and permanent farm improvements which are subject to damage by flooding
4% or less	25 yr.or more	Protection for levees or dikes and other hydraulic structures in agricultural areas

When it has been determined that channel improvement will be needed to meet project objectives, the needs to be served are the primary consideration in selecting the design flood. Where channel improvement will serve for both flood prevention and drainage, the capacity determined by the use of appropriate drainage procedures should be checked by the frequency method to be sure the design also meets the level of flood protection suggested above. If not, the channel should be enlarged accordingly.

C. Survey Detail Recommended -

1. Objectives of the Engineering Survey - The surveys for all types of channel improvement work should be in sufficient detail to:

   a. Determine the condition, gradient, and capacities of existing channels and structures in the channels.

   b. Determine the need for, location of, and design for new channels or improvements to existing channels.

   c. Determine quantities for reasonably accurate cost estimating.

   d. Prepere suitable land rights work maps for use in determining easement or working permit requirements.

These objectives apply to both planning surveys and final design surveys and differ only in the amount of detail and precision needed for the respective stages of project development.

2. Types of Information Needed - To accomplish the objectives stated above, the following information is needed for <u>all</u> types of channel work:

   a. Drainage area at junctions of tributaries and all flow control points. Drainage areas also should be delineated for valley sections used for hydrologic and economic evaluations where these are needed at locations other than at junctions of tributaries and structural control points.

      The drainage area determinations, including those needed for drainage purposes, should be made carefully for use in both the planning and the final design stages of the project. The procedures described in Chapter 1, Part I-D, of this Technical Release may be used.

   b. A profile of the channel showing the elevation of the existing channel bottom, low bank, points of natural low ground away from, but subject to, drainage into the channel, and elevation and dimensions of all structures in or over the channel. In flat areas, occasional topography or perimeter and spot elevations may be needed to determine the drainage pattern.

   c. Representative channel and valley cross sections for each hydraulic and/or economic reach.

   d. The roughness coefficient "n" for each channel and valley cross section. The "n" value should be representative of the hydraulic reach to which the section applies, except that where segments of a cross section differ significantly in flow retardance factors either within the channel, between the channel and the flood plain, or between segments of the flood plain, separate "n" values should be recorded for each segment. (Reference: NEH Section 5, subsection 4.4 and supplement B).

   e. Soil borings at critical points along the proposed channel location. The number and location of borings will be dependent upon soil changes and the possibility of rock, flowing sand, and organic or other unstable material along the proposed channel

right-of-way.

f. Additional channel cross sections may be needed to make reliable estimates of quantities of excavation and clearing, and to determine easement requirements.

g. Stationing and delineation of apparent ownership boundary lines in the vicinity of probable channel improvement work.

h. Other significant features affected such as roads, pipelines, power and telephone lines, buildings, wells, cemeteries, fences, urban development, etc.

Such features should be located on aerial photographs or base maps and the elevations of strategic points recorded.

D. Survey Criteria -

1. Vertical Control -

a. Vertical Datum - For vertical control, mean sea level datum is recommended for all channel improvement work.

b. Bench Marks - It is suggested that reasonably permanent bench marks be established in the work plan stage at tributary junctions, at or near bridges or culverts where channels intersect roads, and at the beginning and end of channels. In addition, temporary bench marks are suggested at approximately one-half mile intervals along the valley to facilitate the survey of valley cross sections and the preparation of an adequate profile.

All bench marks should be set by making turns through the bench marks being set and closing the survey within the required degree of accuracy. They should never be set by side shots from the level circuit. (Refer to Chapter 1, Part I-C-2, for a more detailed discussion pertaining to bench marks.)

c. Permissible Error of Closure - For most channel work, vertical control is of paramount importance. Channel designs are dependent upon the amount of fall between hydraulic control points. Therefore, "third order" or "accurate" leveling (i.e., .05 times the square root of the length of level circuit in miles) should be maintained for all bench level circuits, including sub-circuits within

larger circuits. These bench marks should be established to the specified degree of accuracy in the planning stage for use in both the planning and final design surveys.

2. Horizontal Control -

a. Scaling Aerial Photos - Horizontal control for channel work usually is tied to some form of baseline. In the planning stage, this baseline may be a preliminary centerline located on aerial photographs or an aerial mosaic. The scale of the photographs should be checked in accordance with the method described in Chapter 1, Part I-D-2, of this Technical Release.

For flatland areas, the use of an aerial mosaic (four-inch or eight-inch to one-mile scale), which has been semi-controlled to a USGS quadrangle sheet, is useful in both the planning and final design stages. This aerial mosaic may be used to control open traverse surveys, show apparent land ownership, drainage areas, control elevations, channel locations, etc.

b. Field Survey - In areas where it is difficult to identify points on both the photograph and the ground, or where greater precision is desired, the baseline should be established by an instrument survey. Where the baseline is established by means of a <u>closed</u> traverse survey, the error of angular closure shall not be greater than $1.5 \sqrt{N}$ minutes, N being the number of angles in the traverse. Horizontal closure of chained distances should not exceed 1.0 foot per 1000 feet of traverse length (3.0 feet per 1000 feet for stadia). For <u>open</u> traverse surveys, all angles should be doubled and checked by comparing computed bearings with observed bearings.

All angle points on the traverse should be described and referenced to easily identifiable points so that persons other than those making the original survey can find and make use of them. A minimum of two reference points, which also may serve as bench marks, should be established for any surveyed baseline as well as for each valley cross section.

II - SURVEY PROCEDURES FOR WORK PLAN DEVELOPMENT

A. Location Surveys -

The survey procedure for "Preliminary Surveys" outlined in the National Engineering Handbook, Section 16, Chapter 2, is applicable also in planning watershed projects. Five acceptable methods of performing location surveys are described here. The three methods listed below are suggested for work plan development. The other two methods (4 and 5) are described in Part III of this Chapter for use in final design.

Method 1 - Where suitable eight-inch aerial photographs (or aerial mosaic) are available which show sufficient detail to locate and identify an existing channel that can be used as a baseline, it will not be necessary to run a transit traverse in the planning stage to establish a baseline. Other existing maps or plans of equivalent accuracy sometimes are available and acceptable for this purpose.

After the true scale of the photographs has been verified or determined, the baseline should be stationed with increasing stations in a downstream direction in conformance to Engineering Memorandum SCS-39. The stationing may begin at the centerline of the most upstream floodwater retarding structure with a station number high enough to avoid negative stations in the pool area above the structure.

For projects where only channel improvement is involved, the stationing should begin above the upstream extremity of probable channel work, including work on any laterals. In all cases the stationing should be planned so that there will be no negative stations.

Stationing in a downstream direction is mandatory if water surface profile data is to be computed by means of electronic computer methods. Flood routing procedures also are facilitated by stationing in a downstream direction. An exception to this procedure for stationing may be necessary in some drainage projects where state laws or other legal requirements specify stationing from the outlet in an upstream direction.

The stationing may be accomplished by: (1) Scaling the distances between key points directly on the photographs, (2) ticking a series of short chords and key channel points along the edge of a straight strip of paper, or (3) measuring with a chain or stadia in the field.

To facilitate comparison of channel grades, it is suggested that baselines on tributaries be tied into the baseline on the main channel, using the same station number as the main channel station at the junction point suffixed with the tributary name or letter designation. (Example: Sta. 10 + 62 on the main channel equals Sta. 10 + 62B on tributary "B." Likewise, all other stations on the tributary would show the tributary suffix 9 + 00B, 8 + 00B, etc.) In all cases, the stationing of baselines should conform to existing state laws.

The locations of valley sections are shown next by selecting points on this channel baseline which can be located accurately both on the photographs and in the field. The direction of the valley sections is determined in the field and at the time the sections are surveyed. Where possible the transit should be oriented to photo-identifiable points from which the intersecting angle of the valley section may be determined and plotted on the photograph by use of a protractor. In some densely wooded areas, compass bearings may be the only practical method for orienting the valley section to the photograph.

Method 2 - If suitable aerial photographs are not available, or if the topography or cover is such that the channel and cross sections cannot be located accurately on the photographs, it will be necessary to establish a baseline in the field by means of an instrument survey. Where feasible, the baseline should be located close to the improvement area but outside of brushy or wooded areas and any probable construction areas. This will facilitate survey work and avoid the necessity of establishing a new baseline at the time of construction. This is usually done by staking a series of tangent lines offset a convenient distance from the centerline of the existing channel. It is recommended that all points of intersection (PI's) of the tangent lines be staked with iron pins wherever practicable for later use in final design and construction layout surveys.

Method 3 - Another method of establishing a baseline is by a closed traverse planetable survey, using the telescopic alidade and stadia to obtain distances.

Horizontal control may be established by selecting stations and key points in the area, and tying these points to the baseline. These points should be strategically located on the ground and plotted accurately on the planetable sheet for use as reference in orienting the planetable. Some of these points may be planetable stations required to locate physical features not visible from stations on the baseline.

B. Profiles and Cross Sections -

1. Reaches for Preliminary Design - The length of design reaches normally is governed by the distance between points where a change of elements of the channel occurs, such as the entry of a side tributary or a change in gradient, depth, width, etc. Where the elements of a channel are constant for relatively long distances, the reach lengths should be subdivided so that no design reach will exceed about one mile in length. For most drainage projects, a maximum length of one-half mile is recommended. Keeping reach lengths short will permit more flexibility in design.

2. Survey of Valley Sections - The survey of valley cross sections used to develop water surface profiles for damage evaluation should be extended high enough on each side of the valley to be above the maximum high water mark and permit computation of flood-plain storage. Where drainage also is needed, the valley sections must extend across the area to be drained to define the drainage pattern and permit design of the lateral system. Normally, this work is done in sufficient detail in the planning stage to serve for both the planning and final design requirements.

   Sufficient points should be surveyed to represent adequately the hydraulic characteristics of the cross section. Elevations should be established at any significant changes in slope. The distance between points on the cross section should not exceed 300 feet where the slopes are relatively uniform. The elevations and distances may be established with the use of transit and stadia, planetable alidade and stadia, or a level and tape. All valley cross sections should be tied into the baseline as described under "Location Surveys."

3. Additional Channel Sections - Additional channel sections may be required to make reliable estimates of quantities and to determine easement requirements. They should extend far enough to permit improved channel alignment without additional surveys or at least 50 feet beyond the expected right-of-way, whichever is greater. The allowable distance between cross sections will vary with channel and valley conditions. Normally, 300 to 1000 feet is sufficient for work plan estimates. These sections should be tied into the same basic datum as the other sections in the watershed.

C. Hydraulic Structures -

1. Bridges and Culverts - Adequate survey data is needed for all bridges and culverts in order to compute the carrying capacity for each. A minimum of three cross sections is needed at each structure; i.e., an inlet or approach section, a section perpendicular to the direction of flow through the structure, and an exit section. The entrance and exit sections usually are taken approximately 50 feet from the respective ends of the structure. The section through the structure should include the size of the opening, abutment footing elevations, and elevations of the bottom of bridge girders and the road surface. This section should be extended along the centerline of the road on either side of the structure beyond any probable overflow elevations. The grade and length of all bridges and culverts also should be obtained.

2. Grade Control Structures - The three sections described for bridges and culverts also should be taken for all grade control structures along the channel. Similarly, cross sections are needed for all rock ledges which act as grade or hydraulic control sections.

D. Plotting of Data -

Plan, profile, and cross-section data obtained during the planning stage should be neatly plotted for use in final design. Figure 1, attached, shows an example of a plan and profile of a typical channel improvement project. Figure 2 illustrates a standard method of showing cross-section data.

1. Plan Data - The plan should show the location of the existing channel; baseline; cross sections; proposed channel, dikes, etc.; apparent property lines; cultural treatment of adjacent lands; bench marks; roads, including bridges and culverts; and any utilities that are within the planned right-of-way. It also is very desirable to show the key flood or design flood line on the plan. The baseline should show either azimuths or the deflection angles at any changes in alignment or the proposed channel may be shown as traced from aerial photographs. Where applicable, curve data also may be shown. The direction and stationing of the cross sections should be shown on the plan. The plan may be made from an overlay of corrected eight-inch aerial photographs, planetable sheets, or a plot made from transit survey field notes.

2. Profile Data - Data obtained from the survey of valley cross sections and cross sections surveyed at hydraulic structures, supplemented if necessary with information from available USGS quadrangle sheets, should be used to plot a profile of the existing channel and valley. Standard sized sheets of plain profile paper or plan-profile paper (illustrated by Figure 1) should be used for this purpose.

   The profile should show the water surface of the key flood or the design flood for both present and future conditions; the present ground line; the existing and proposed bottom grade; the proposed hydraulic grade line; cross-section locations; soil boring data; the elevation and location of any exposed or underground utilities, roads, and existing or proposed bridges, culverts, junctions of tributaries; etc. The reaches to be cleared and snagged also should be shown on the profile. If the proposed improvement does not follow the existing channel, the stationing and profile along the centerline of the proposed channel should be used.

3. Cross Sections - All channel sections should be plotted on standard cross-section paper using 1"=10' or 1"=20' for both the vertical and horizontal dimensions. These sections should show any existing channels; the intersection with the baseline; the elevation of the key flood and the design flood for both existing and future conditions; the elevation of any exposed or underground utilities, etc.; and any existing or proposed bridges, culverts, etc. The heights, top widths, and side slopes of all dikes, levees or diversions should be shown. The lateral extent of all clearing and snagging must be shown on the cross sections.

   Usually, it is more convenient to plot each valley section on a separate 11" X 14" sheet. A vertical scale of 1"=10' or 1"=20' may be used with whatever horizontal scale is most convenient. A true scale of the associated channel section also may be plotted on this same sheet to facilitate computation of hydraulic parameters. If the electronic computer is used to compute the hydraulic characteristics of the valley, it is not necessary to plot valley sections.

E. <u>Documentation of Data</u> -

All supporting data developed during the planning phase should be properly documented and filed. This will insure that such data will be of maximum use for future reference. All notes and computations should be properly identified

and be complete so that they can be checked by engineers working on detailed plans for design and construction. The data should be dated, since Service criteria is modified from time to time. All papers should show the initials of the person preparing the data sheets or making the computations. A reference should be made to indicate the methods or source of data used.

III - SURVEY PROCEDURES FOR FINAL DESIGN

A. <u>General Requirements</u> -

The section covering "Design Surveys - Surface Drainage" in the National Engineering Handbook Section 16, Chapter 2, will serve as a useful reference for final design surveys for most of the channel improvement work in watershed projects. <u>As indicated in the N.E.H., a staked baseline is required</u>. An exception to this requirement may be made where clearing and snagging is the only work needed to provide the desired level of protection. For this condition, no additional surveys over those recommended for work plan development may be needed for design purposes. However, surveys for clearing and snagging must show that this treatment will result in a stable channel that will meet the desired project objectives.

B. <u>Supplementing Work Plan Surveys Made by Instrument Surveys</u> -

If instrument surveys were made to develop the work plan in accordance with either Method 2 or 3 described in Part II of this Chapter, the data obtained for the work plan may be used for final design plans. Usually, it is desirable to supplement the channel cross-section data with additional sections at 100-200 foot intervals to firm up the alignment on curves, etc., and to obtain an accuracy in estimates of "planned quantities" of excavation within the allowable 2.0-percent accumulative error described in N.E.H.(Section 16, Chapter 2, p. 2-21). Additional borings also may be needed.

C. <u>Supplementing Work Plan Surveys Made by Aerial Photograph Method</u> -

If the eight-inch Aerial Photograph Method (Method 1) was used to develop the work plan, a baseline may be staked in the field in accordance with Method 2 supplemented with additional surveys as described in paragraph III B.

Where new channel alignment is needed in areas of heavy woods, one of the following alternative methods may be more desirable.

Method 4 - Random Transit-Stadia Survey - Stake a random line outside the heavy growth area. Carry elevations and distances by transit-stadia and record azimuths, bearings, or deflection angles of the random line. Tie in all valley cross sections used to develop the work plan, including the intersection of the proposed channel centerline with the valley cross sections.

Compute the distance and bearing of the channel centerline between intersection points on the valley cross sections by the latitude and departure method. Lay out the channel centerline using the azimuths computed from the computed bearings, taking enough random shots to determine any necessary changes in alignment between cross-section points. After the final centerline has been determined, survey any additional cross sections needed to determine final estimates of excavation quantities.

Method 5 - Transfer of Aerial Photograph Layout to Field Layout - From the layout of the proposed centerline of the channel on corrected eight-inch aerial photographs, select a starting point on the centerline that can be accurately located both on the photograph and in the field. Also, locate two physical features on the photograph that can be seen from the starting point in the field. Draw a north-south line through the starting point on the photograph and determine the azimuth of the lines from the starting point to the two selected physical features by use of a protractor. Determine the azimuth of each tangent of the centerline. This can be done most readily by measuring the right or left deflection angle at each PI and adding (right) or subtracting (left) it from the previous azimuth. Use the length of each tangent as scaled on the photograph during the work plan stage.

Set up the transit over the selected starting point and orient it for azimuth by sighting the two selected physical features. Lay out the centerline by transit-stadia survey using the azimuths and distances as laid out on the photographs. Sufficient random shots should be taken to determine the final alignment of the centerline. Stake the final centerline or offset line and take the necessary additional cross sections.

D. Land Rights Work Maps -

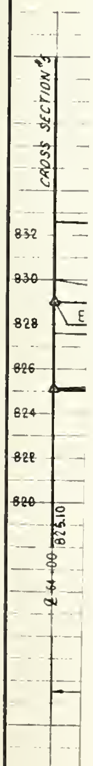
With the work plan data plotted to include the detail described in Part II of this Chapter, the land rights work map may be obtained by making an overlay of the appropriate portions of the plan or aerial photographs. Judgment must be exercised to insure that adequate right-of-way is provided,

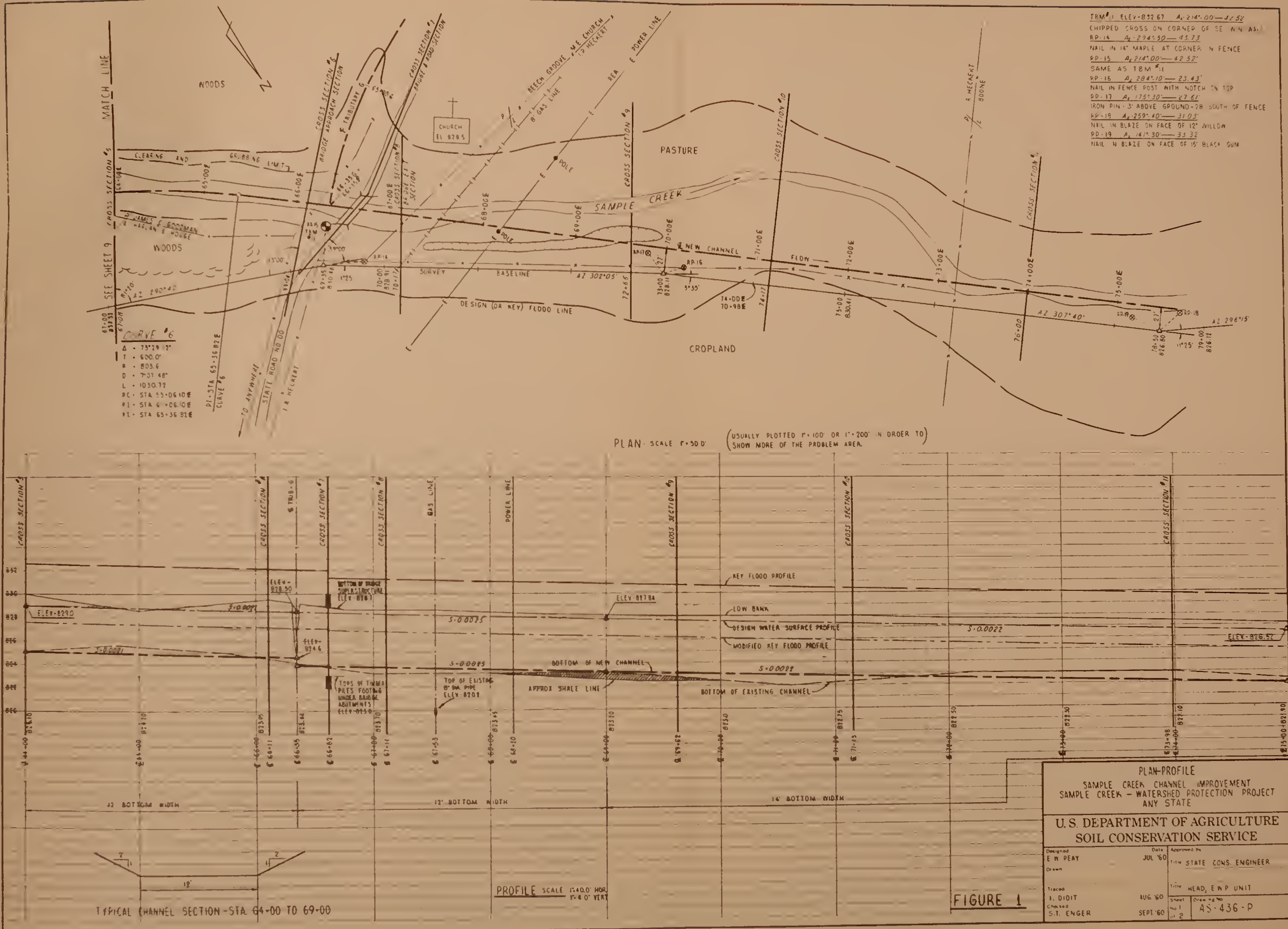
not only for the channel and spoil bank area but also for any area needed to operate various types of earth-moving equipment.

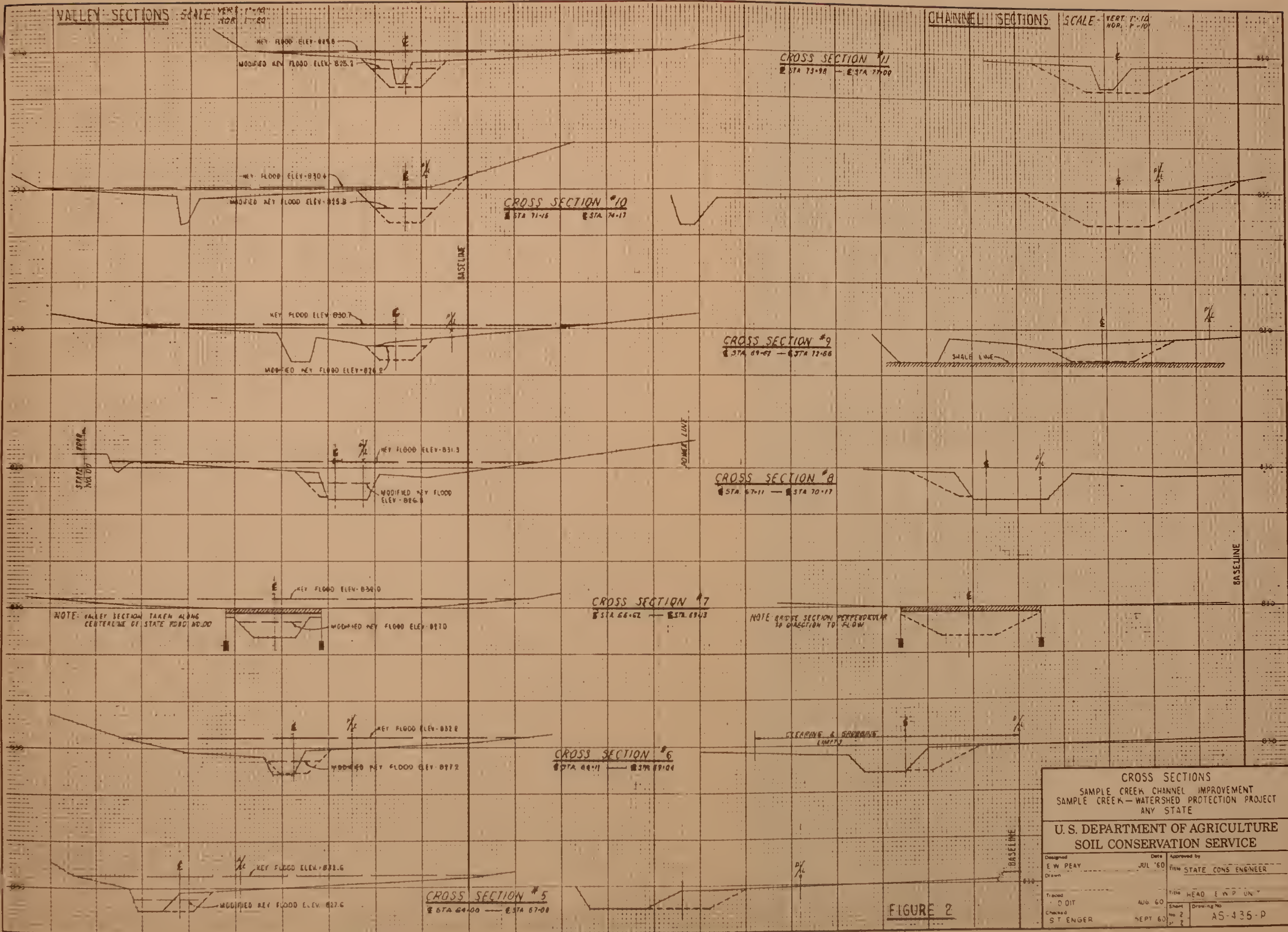
If the proposed works of improvement consist of modifying the existing channel, the right-of-way requirement can be stated as a given distance from either side of the center-line. If the works of improvement consist of channel re-alignment or dikes, levees, or diversions, the right-of-way requirement usually will be stated as a given distance from either side of the baseline. <u>The baseline then must be properly referenced to all apparent property lines by sta-tioning and angular measurement</u>.

Except where specified otherwise in existing state laws, the land rights work map should show the existing channel, utilities, apparent ownership boundaries, roads, baselines showing key stations, and proposed works of improvement. If requested by the sponsors or required by state law, the apparent acreage of right-of-way for each landowner should be indicated on the land rights work map. Usually, it will not be necessary to show the azimuths, cross sections, and curve data on the land rights work maps.

A typical cross section should be shown on the land rights work map to illustrate the various elements of the proposed works of improvement within the right-of-way area. When utilities are involved, the actual cross section including the elevation of the design flow should be shown at the intersection with the utility.


CROSS SECTION #3
832
830
828
826
824
822
820
825.10


TBM #1 ELEV-832.67 Az 214°00'—42.52
CHIPPED CROSS ON CORNER OF SE WING WALL
RP-14 Az 294°50'—43.73
NAIL IN 14" MAPLE AT CORNER IN FENCE
RP-15 Az 214°00'—42.52'
SAME AS TBM #1
RP-16 Az 284°10'—23.43'
NAIL IN FENCE POST WITH NOTCH ON TOP
RP-17 Az 175°30'—27.61'
IRON PIN - 3' ABOVE GROUND - 28 SOUTH OF FENCE
RP-19 Az 259°40'—31.03'
NAIL IN BLAZE ON FACE OF 12" WILLOW
RP-19 Az 141°30'—33.32
NAIL IN BLAZE ON FACE OF 15" BLACK GUM
MATCH LINE
SEE SHEET 9
WOODS
CHURCH
EL 828.5
BEECH GROOVE M.E. CHURCH
REA POWER LINE
8" GAS LINE
PASTURE
SAMPLE CREEK
NEW CHANNEL
FLOW
SURVEY BASELINE
AZ 302°05'
AZ 307°40'
AZ 296°15'
DESIGN (OR KEY) FLOOD LINE
CLEARING AND GRUBBING LIMIT
CROPLAND
CROSS SECTION #5
CROSS SECTION #6
CROSS SECTION #7
CROSS SECTION #8
CROSS SECTION #9
CROSS SECTION #10
CROSS SECTION #11
BRIDGE APPROACH SECTION
BRIDGE & ROAD SECTION
TRIBUTARY
STATE ROAD NO 00
TO ANYWHERE
CURVE #6
Δ = 73°29'12"
T = 600.0'
R = 803.6
D = 7°07'48"
L = 1030.72
PC = STA 55+06.10E
PI = STA 61+06.10E
PT = STA 65+36.82E
PLAN SCALE 1" = 50.0'
(USUALLY PLOTTED 1" = 100' OR 1" = 200' IN ORDER TO SHOW MORE OF THE PROBLEM AREA.
GAS LINE
POWER LINE
KEY FLOOD PROFILE
LOW BANK
DESIGN WATER SURFACE PROFILE
MODIFIED KEY FLOOD PROFILE
BOTTOM OF NEW CHANNEL
BOTTOM OF EXISTING CHANNEL
APPROX SHALE LINE
ELEV-829.0
ELEV-817.84
ELEV-826.52
S = 0.0025
S = 0.0022
S = 0.00085
S = 0.00092
TOPS OF TIMBER PILES FOOTING UNDER BRIDGE ABUTMENTS
TOP OF EXISTING 8" GAS PIPE ELEV-820.2
12' BOTTOM WIDTH
14' BOTTOM WIDTH
TYPICAL CHANNEL SECTION - STA 64+00 TO 69+00
18'
PROFILE SCALE 1" = 40.0' HOR. 1" = 4.0' VERT.
PLAN-PROFILE
SAMPLE CREEK CHANNEL IMPROVEMENT
SAMPLE CREEK – WATERSHED PROTECTION PROJECT
ANY STATE
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed E W PEAY Date JUL '60
Drawn
Traced I. DIDIT AUG '60
Checked S.T. ENGER SEPT. '60
Approved by
Title STATE CONS. ENGINEER
Title HEAD, E W P UNIT
Sheet No 1 of 2
Drawing No AS-436-P
FIGURE 1



VALLEY SECTIONS
CHANNEL SECTIONS
CROSS SECTION #11
CROSS SECTION #10
BASELINE
SHALE LINE
CROSS SECTION #9
POWER LINE
CROSS SECTION #8
CROSS SECTION #7
CROSS SECTION #6
CROSS SECTION #5
FIGURE 2
CROSS SECTIONS
SAMPLE CREEK CHANNEL IMPROVEMENT
SAMPLE CREEK—WATERSHED PROTECTION PROJECT
ANY STATE
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
E W PEAY
JUL '60
STATE CONS ENGINEER
S T ENGER
SEPT 60